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ESTABLISHING REQUIREMENT IN TEACHING NEW AND RENEWABLE ENERGY

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ABSTRACT

The distinctive shortage in the availability of skilled labor in new and renewable energy sector becomes the issue that has been prevented this country in achieving the national energy mix in 2015 and 2050. Although both formal and non-formal education initiatives already exist to foster new and renewable energy education, the number of graduates cannot outpace the number of required labor. The number of graduates and their competencies must be considered because local labors are facing intense competition with foreign labors due to ASEAN Economic Community policy. This research aims to find a solution to address the educational issue in new and renewable energy education. This research is using iterative methodology from the software engineering domain to identify issues and problems in new and renewable energy education in Indonesia and suggested alternatives to address it. Combination of techniques (questionnaire, interview, studying documentation, and research a similar product) is used in requirement elicitation stage in order to provide multiple perspectives.

Kata kunci: *e-learning; virtual environment; new and renewable energy; requirement engineering; education; software engineering.*

1. INTRODUCTION

Indonesian government set the target for new and renewable energy (NRE) is expected to be 23% in 2025 and 31% in 2050. One of the challenges in achieving the national energy mix target is lacking human resources in the domain of NRE [1]. The development in NRE domain opens many job opportunities. However, the distinctive shortage in the availability of skilled labor becomes the issue that has been prevented the NRE sector from realizing its potential as the driving force behind the country's continued economic growth [2]. Moreover, ASEAN Economic Community policy makes the competition tighter. Without sufficient skills and knowledge in the domain of NRE, the labor market will potentially be dominated by a foreign worker.

Currently, several programs and initiatives already exist to foster renewable energy education in Indonesia, such as formal education and non-formal education. In the formal education sector, there are several programs/centers for renewable energy studies offered. The level of education also varies from diploma (D3 / D4), undergraduate (S1) and postgraduate (S2) program [3]. The Ministry of Education and Culture continues to develop vocational schools in Indonesia. The latest plans are to create 100 vocational high schools (SMK) majoring in renewable energy engineering and covers NRE domain in the curricula of existing vocational school [4].

Some non-profit organizations also provide various initiatives as a catalyzing effort in training the next generation of energy professionals and promoting renewable energy innovation. Lentera Angin Nusantara (LAN) initiated in 2011 as a forum for self-potential development through technology, aims to contribute to the development of the country and resolve energy-related problems in underdeveloped regions and the remote islands of Indonesia. Besides research and development (RnD) in Wind Turbine technology and community development, LAN opens its RnD sites in Ciheras Tasikmalaya for student internship and workshops [5]. Energy Academy Indonesia (Ecadin), a platform for discussion and

knowledge exchange between academia, industrial practitioners & players, regulation makers, and spectators in tackling energy-related issues in Indonesia, mainly utilize online media such as webminars and videos shared on Ecadin channels, including official pages, Facebook, Youtube, Instagram and Twitter in sharing information and knowledge [6]. Yayasan BAKTI shares animated videos and comics about NRE through its green knowledge program. Indonesia faces the need to expand opportunities for non-formal education and training [7][8]. All of these methods are effective enough to disseminate information and increase public awareness and concern for the NRE domain but unsuitable in fostering renewable energy education because the topics discussed in those channels are general information.

Formal educations are insufficient to strengthen the capacity of human resource, science, and technology in the NRE domain because of the limited number of graduates. On the other hands, non-profit organizations efforts reach far more participants but are considered ineffective in fostering renewable energy education. Therefore, we face the need to expand upon its non-formal education and training opportunities. The objective of this study is to identify the potential solution to educate people in Indonesia and provide competitive local labor in the domain of NRE by utilizing technology. The rest of this paper is organized as follows. Section 2 describes the research methodology that this study employs; the results and analysis are presented in Section 3; the paper concludes in Section 4.

2. RESEARCH METHODOLOGY

In software engineering [9][10], some preliminary activity, requirement engineering, must be performed before we can provide solution options. Gathering requirement is considered as the most crucial part in software engineering [10]. It is because we need to understand as much as possible about the users, their activities, and the context of that activity, so the system under development can support them in achieving their goals. The system requirements are deriving through observation of existing systems, discussions with potential users and procurers, task analysis. Once we got data from requirement elicitation, we performed analysis. The analysis results led us to the possible solution options.

There are three generic software engineering methodology, the waterfall model, agile, and incremental [9]. This research combines incremental and waterfall model, as shown in Figure 1. The activities in the requirements process are not merely carried out in a strict sequence. Instead, the activities of elicitation, analysis, and interpretation are interleaved. Requirements analysis continues during definition and specification, and new requirements come to light throughout the process.

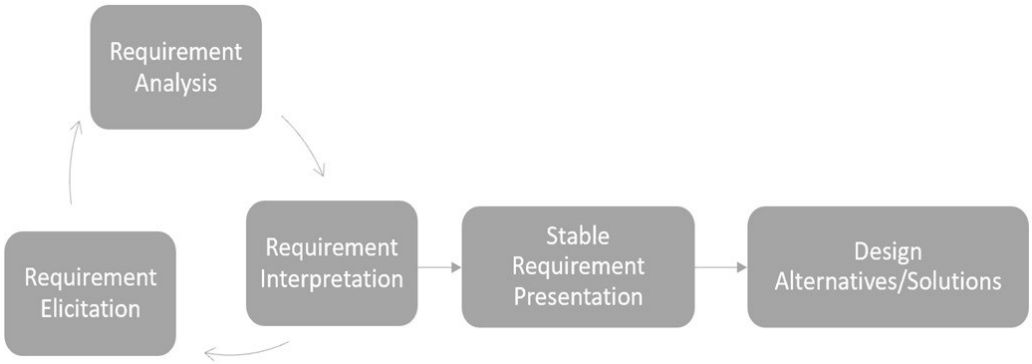

Figure 1. ***Research Methodology***

We collected sufficient, relevant, and appropriate data by combining questionnaire, interview, and studying documentation and research similar product in requirement elicitation so that a set of stable requirements can be produced [10]. Combination of techniques provides multiple perspectives. Questionnaires were used to explore the issue, and interviews were performed to understand the context of user activity and studying documentation to cross-check and richen the data.

Requirement analysis in this research was performed using simple qualitative analysis approach. This approach provided a comprehensive account of the behavior being observed. In analyzing quantitative data, we identified a recurring pattern in the questionnaires and interviews result, categorizing data, and looking for critical incident [10] then grouped the findings to generalize the description.

Interpretation of the findings proceeds in parallel with analysis. In order to have a more accurate interpretation result, we looked at other data. We studied documentation from Ministry of Education and Culture and Ministry of Research, Technology and Higher Education about new and renewable energy education and research Massive Open Online Course and other non-government organization approaches

to educating people about new and renewable energy. The result of analysis and interpretation then presented as summary findings.

Based on the summary findings, we researched similar products to assess technical and operational feasibility to implement the solution and add non-functional requirements, data requirements and environmental requirements into the stable requirements.

3. RESULTS AND ANALYSIS

Qualitative questionnaire for energy subject course in Universitas Pertamina is utilized for this research. The questionnaire was distributed since 2016 two times in each semester to identify student's issues and problem to understand the subject. This questionnaire is a part of continuous improvement effort for the university in delivering the course material. A total of 1677 responses are collected from this questionnaire. This course is provided during the freshman year, so it is assumed that the respondent does not have depth knowledge about the subject. Figure 2 shows that the majority of students give an opinion about the teaching method, followed by time and some technical things in the class, which mostly complaining that the teachers need to speak louder. The sentiments for each category is drawn in Figure 3. It is shown that most of the opinion is positive about the teaching method. The detail of positive and negative sentiment is generalized in Table 1.

Interviews are performed with the founders of a non-government organization (NGO) that works in the new and renewable energy domain, Ricky Elson from Lentera Angin Nusantara and Desti Alkano from Energy Academy Indonesia. The result from requirement elicitation is presented in a list of issues and problems as well as good things that should be maintained, as shown in Table 1.

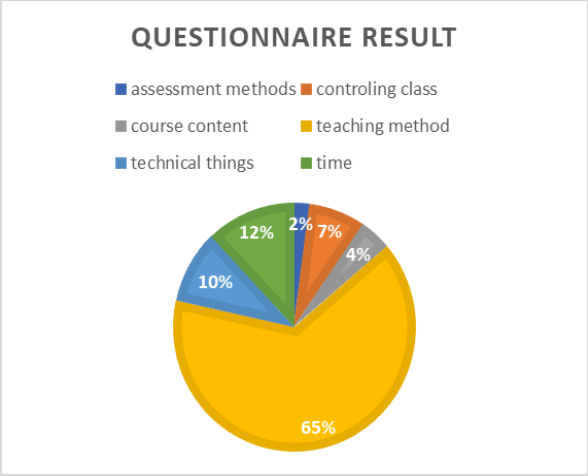

Figure 2. Survey Result From Class-Based Energy Related Course Based On Topics

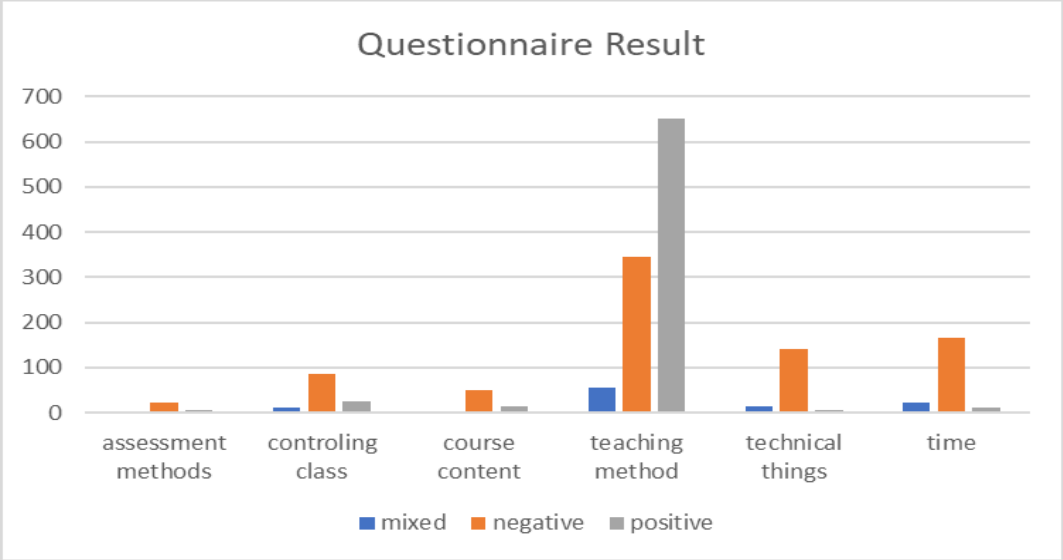

Figure 3. Survey Result From Class-Based Energy Related Course Based On Sentiments

3.1 Identified Problems Based On Requirement Elicitation

Findings from the questionnaires and interviews are presented in Table 1 and Table 2. Table 1 lists the issues and problem in teaching/learning new and renewable energy, while Table 2 consists of good things that should be kept in the future learning approach. Table 1 and 2 show the recurring comments found in the questionnaire as well as some concern, issues, and problem gained from interviews. New and renewable energy is not a popular concept that we can find in our everyday life.

Table 1. The identified problems

No	*Problem Description*	*Source*
1	Some learners require examples to understand the course	Questionnaire
2	Some learners need a simple explanation for unfamiliar concepts	Questionnaire
3	Some learners, specifically from social science, find it is difficult to follow an explanation with too many technical terminologies.	Questionnaire
4	Some learners faced technical issues in doing online quizzes.	Questionnaire
5	Some learners suggest increasing the number of discussions and focus group discussion in class	Questionnaire
6	The structure in some presentation slides is impressive, while others are difficult to follow.	Questionnaire
7	Some teachers are boring, particularly when they just read the material from the slide while some others can make the class more interactive	Questionnaire
8	Weekly quizzes and assignments helped them to have a better understanding of a topic, and it make them more prepared for the mid or final test.	Questionnaire
9	Some teachers are considered to fast in explaining the material	Questionnaire
10	Practical issues such as; presentation slides contain too many texts, text too small.	Questionnaire
11	Some learners prefer the presentation slide in Bahasa	Questionnaire
12	Some materials need a laboratory session	Questionnaire
13	In learning a new topic, laboratory session has time limitations, and its only perform experiments toward certain variables.	Interview
14	There are some online courses about new and renewable energy from reputable universities. Unfortunately, most of the courses require the participant to pay in order to get a certification.	Interview
15	Online courses about new and renewable energy are delivered in English. It adds difficulty to understand the new and unfamiliar concept.	Interview
16	Most experts in new and renewable energy have their professional job either in Indonesia or abroad. It needs long and a lot of preparation to arrange face-to-face training.	Interview
17	Knowledge and information that was shared by some of the non-governmental organization are general. They have not shared any specific, detail, and continuous material about a particular topic or technology in the new and renewable energy domain.	Interview
18	LAN provides an internship program where participants research about a specific technology. Unfortunately, it can only accommodate 20- 40 participants at the same time.	Interview
19	Sometimes there was an internet connection problem during the webminar session.	Interview
20	The face-to-face seminar requires more resources, particularly money, than the webminar	Interview

Based on findings in Table 1, in general, students find it difficult to imagine, relate, and understand the concept when the lecturers use technical terminology as shown in problem description number 1, 2, 3. We can conceive that activities that require learner's involvement improves their understanding and helps them retain the information/knowledge longer from problem description number 5,8,12. Other students provide feedback about the technical and practical issues such as problem description number 4, 6, 7, 9, 10, 11.

Table 2. Positive findings

No	*Description*	*Source*
1	Teachers who are enthusiast makes the class session vibrant	Questionnaire
2	Learners enjoy gamification methods in the class, using Kahoot for online quizzes	Questionnaire
3	Using analogy in explaining a concept make learners easy to understand the concept	Questionnaire
4	Video, simulation, illustration, and games make the class session lively, maintain learners' interest and made them curious about the topic	Questionnaire
5	e-learning helps them to find the presentation slides and other materials for each class session	Questionnaire
6	Technology such as online meeting enables many people in different locations meet at the same time with the minimum cost required	Interview
7	Using the online method, we can reach much more participants compared to the traditional way	Interview
8	Technology such Internet enables information available for the public and can be accessed anytime	Interview
9	In an internship program, the participant can design a specific technology, implement their design, as well as monitor and evaluate their implementation in a real condition. It is a better approach to build a mental model compared to a laboratory session where the participant can only monitor a phenomenon in a limited time and controlled environment.	Interview
10	When a participant cannot join the live webminar, they can find the recording in an online channel such as YouTube	Interview

Table 2 shows that technology helps in spreading knowledge and information. Analogy, examples, video, illustration, and simulation helps them to relate the concept as stated in Positive Findings number 2, 3, 4 can become a solution for problem description 1, 2, 3 in Table 1. Using technology, we can reach many people located in various location (Positive Finding 6,7,8, 10). These findings can address identified problem number 16, 17, 18, 19, and 20. However, we need to consider some technical limitation, as mentioned in problem number 4, 19. Furthermore, the availability of recorded live session for public provides flexibility for people that having time difference when the event took place.

Positive findings number 6, 7, and 8 which are gained by Energy Academy Indonesia aligns with findings in

Another education method, Internship program, also has its superiority compared to experiments in the laboratory. With a duration of about 1-3 months, the participant can implement their prior knowledge in a real project. Additionally, they can monitor and evaluate their works in a real condition in a longer duration (weeks or even months). In the real condition, no variables are isolated, which might lead to a different result with the experiments in the lab, new phenomenon findings, or better understanding about the relationship among variables.

3.2 Analysis and Interpretation

Both positive and negative findings from requirement elicitation are grouped, generalized, prioritized, and presented in a table of summary in Table 3. The prioritization is performed based on technical difficulty.

Table 3. Findings categorization and prioritization

No	*Description*	*Domain Area*	*Source*	*Priority*
1	Unstandardized pace and teaching method among lecturers	Material Delivery	Questionnaire	Low
2	Difference learning pace among learners	Material Delivery	Questionnaire	Low
3	Using Bahasa in delivering the material	Material Delivery	Questionnaire and Interview	Low
4	The unstandardized of the structure in the material slide	Material Delivery	Questionnaire	Low
5	Different learning style among learners (visual, auditory, kinesthetic)	Material Delivery	Questionnaire	Medium
6	Various types and level of exercises are needed to help learners build their mental model	Tools	Questionnaire	Medium

No	*Description*	*Domain Area*	*Source*	*Priority*
7	Laboratory session can imitate the real-world condition if complete and accurate data are available despite its high cost	Tools	Interview and Analysis	High
8	Simulation enabled learners to monitor and evaluate specific phenomenon that happened in a long period in the real world within a shorter period despite its dependency to accurate and reliable data	Tools	Interview and Analysis	High
9	The proposed solutions should consider technical and practical issues such as: Internet connection reliability, The number of concurrent users	Tools	Questionnaire and Interview	High
10	Need an in-depth training/courses about basic concept and technology in the new and renewable energy domain	Content	Interview	Medium
11	Need a certified program that acknowledged by industry and Ministry of Research, Technology and Higher Education	Content	Interview	Low
12	Hands-on experiences are needed in a particular training/course	Content	Interview	High
13	The courses/training should be asynchronous to accommodate people despite from various locations and time difference	Accessibility	Interview	Low
14	The certification program fee must be reasonable for people who cannot afford formal education	Accessibility	Interview	Low

In table 3, category 5 and 6 are generalized from problem number 1, 2, 5, 8, and positive findings number 2, 3, 4. Some issues in delivering the material to students as mentioned in problem number 6, 7, 9, 10, 11, 15 which can be tackled using positive findings number 1, 5, 10 are accommodated in category 1, 2, 3, 4. Additional activities, as mentioned in problems number 12, 13, and positive findings number 9, are addressed in category number 7, 8, 10, 12. Last, problem number 4, 19 limits the positive findings number 6, 7, 8, and 10 to address problem number 16, 17, 18, and 20 should. These are summarized in category 7 to 14.

3.3 Requirements

User requirements which describe the functional and non-functional requirement is written down in Table 4. These requirements are obtained from the problem and findings prioritization in Tabel 3. This user requirement should be expanded into system requirement once the proposed solution is selected. This process is not covered in this paper.

Table 4. List of stable requirement

No	*Requirement Description*	*Domain Area*
1	Provide a web-based in-depth training/courses about basic concept and technology in the new and renewable energy domain	Functional
2	The training/course must be delivered in Bahasa or have a subtitle in Bahasa	Functional
3	Able to display text, illustration, animation, video, or simulation for a particular topic to accommodate the various learning style	Functional
4	All material can be downloaded to accommodate learners that have various learning pace. So that the learners can revisit it.	Functional
5	Provide a different level of assessment from easy to difficult for each topic	Functional
6	Provide various ways to assess learners, such as Pop quizzes, Multiple choices Essay, Short answer	Functional
7	Provide a mechanism to track learners' progress	Functional
8	When using a slide, a maximum of 6 lines in a slide	Functional
9	Provide an alternative to the laboratory session	Functional
10	The solution should provide two different roles: lecturers, students	Functional
11	The lecturer should be able to upload the material in various formats (text, video, audio), grade any assessments, open or create assessments for a specific period, and check student's progress.	

No	*Requirement Description*	*Domain Area*
12	Should be able to track student's progress	Functional
13	Should be able to record and check user credential	Functional
14	Should be able to record assessment result for each user	Functional
15	Should be able to mitigate the risk of information security threat by using required hardware and software to protect the confidentiality, integrity, authentication, and nonrepudiation	Non-Functional
16	Should have high reliability and availability of internet connection with Service Level not less than 95%	Non-Functional
17	Should have high scalability of IT infrastructure to provide more than 1000 concurrent users	Non-Functional
18	Should provide an acceptable level of response time (< 3 seconds)	Non-functional

3.4 Proposed Solutions

Based on requirements written in Table 4, there are several alternative solutions to fostering renewable energy education using online method such as utilizing open-source e-learning platform, improving the content of existing webminar provided by one of the NGO, using animated video to help participant understanding, and create virtual environment for online learner as a substitute of laboratory activities. Table 5 describes the advantages and disadvantages of each option.

Table 5. Solution options

Option	*Advantages*	*Disadvantages*
e-learning platform	• Provide a standardized structure of topic in one subject. • Accommodate various types of course delivery methods such as; text-based, audio, visual, and video (audio-visual). • Accommodate various assessment methods, such as; multiple-choices quiz, open question quiz, and essay.	• Cannot replace the laboratory activities that are required in particular topics/subject.
Webminar content improvement	• Low technical difficulty to implement. • One of NGO have adopted this solution, and it shows that relatively easy to use.	• No assessment tools, so we cannot assess the participant's understanding • Participant passively listen to the explanation, considerably ineffective to build a mental model about a subject.
Use animated video as a supplementary teaching method	• Helps participants to visualize unfamiliar concept, object and process. • Helps visual learner participant.	• No assessment tools, so we cannot assess the participant's understanding.
Virtual environment as an alternate of laboratory activities	• Involves participant to learn a subject actively. • Enables participant to observe a behaviour/pattern that requires a significant amount of time in the real world • Helps kinaesthetic learner participant.	• Can only be used as a complementary method in teaching as participant requires an introductory discussion. • Requires very detail data to create a representative model.

Animated video and virtual environment help learners visualize unfamiliar concent and build their mental model because it requires learner's active participation. Other researches successfully build the virtual environment to support the learning process [11], [12]. Combine with technology such as e-learning or webminar these solutions reach much more participants and provide flexibility in term of time for the participant. However,it can only be achieved when the infrastructure for the internet is reliable, and the participant has a good level of computer literacy [13].

4. CONCLUSION

The combination of e-learning can be an ideal solution to address the problem in NRE education. It provides various teaching methods, such as text-based, lecturing video and animated video, and virtual environment. The proposed solution can reach more participants with a broader range of areas and minimum costs compared to traditional in-house training. However, these benefits can only be achieved when the participant has a good level of computer literacy and having a reliable infrastructure. Another limitation in Indonesia is data availability. Without the availability of precise data, the virtual environment cannot simulate the real condition. Collaboration and coordination among various parties (central and regional authorities, Meteorological, Climatological and Geophysical Agency, academia, and industry) are needed in addressing this issue. Furthermore, complete, precise, and fine-grained data will not only useful in developing a virtual environment but also support the policy and decision-makers make a more well-informed decision. It also helps the industries to see opportunities in the field of new and renewable energy.

Further studies are needed to measure the effectiveness, public acceptance, and sustainability of the solution and as a part of continuous improvement.

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